APPENDIX C: ZINTEL CANYON PROJECT

C-1. Project Description

a. General. The Zintel Canyon Project (Figures C-1 through C-4) was authorized for construction by resolution of the House and Senate Committees on Public Works, December 1970, under authority of section 201, Flood Control Act of 1965 (Public Law 298, 89 Congress). The project was constructed substantially as authorized. Detention storage was reduced from 2,560 to 1,260 acre-ft since this was considered the optimum economic size of the dam. This alternative will not prevent damages in some areas of Kennewick or avoid the use of streets as a channel during flooding in excess of 50 years (100-year thunderstorm). Zintel Canyon Project includes a dam and a floodway channel with required structures that carry the combined flows from the dam and areas below the dam through a developed section of Kennewick to a discharge point at the Columbia River. Zintel Canyon Dam is a 90-ft retention straight axis concrete gravity structure totaling approximately 70,000 cu yd of roller compacted concrete (RCC). The purpose of the dam is to provide flood protection to the city of Kennewick, Washington, by impounding flood flows behind the dam up to the 100-year return frequency, and discharging that volume over a 20-day period. The Floodway Channel improvements consists of a buried conduit designed to pass up to a 50-year composite flood level. The 78-in. buried conduit is designed to carry 400 cfs from its intake at West 7th Avenue and Vancouver to the outlet in the Tri-City Country Club Golf Course. From there the natural channel is designed to pass 620 cfs through the Burlington Northern railroad fill (Figure A-1). Downstream of the railroad fill the channel is designed to provide standard project protection. The project is co-funded by the U.S. Army Corps of Engineers (75 percent) and the city of Kennewick (25 percent). The project is located in a semi-arid region of eastern Washington and borders on the south end of Kennewick, Washington. The basin, a well defined water course called Zintel Canyon, is normally dry and drains approximately 28 square miles of the north side of the Horse Heaven Hills of which approximately 19 square miles in area is upstream of the dam. The drainage upstream of the dam collects winterstorm and thunderstorm runoff, thereby providing a 100-year flood storage volume of 1,260 acre-ft.

b. Geology and foundation. Zintel Canyon is located on the southwest flank of the Pasco Basin, a structural feature formed by downward folding and faulting of the Columbia River Basalt formation. Erosion and deposition has modified the structural features by partially filling the basin with sediments and covering the rock slope with a mantel of fine-grained materials. Bedrock is close to the surface within the drainage area of Zintel Canyon and where the dam was located. The foundation rock was composed of hard, dense basalt with closely spaced fractures. The moderately unweathered pieces were bounded by weathered fracture surfaces. Fracture fillings, particularly near the surface, were filled with silt and clay. Because the rock would easily dislodge when the joint filling dried, as well as from subsequent construction activities, the exposed foundation rock was covered with a minimum 8-in. layer of pumped concrete prior to RCC placement.

c. Dam, spillway and outlet. The dam is a straight axis concrete gravity structure with a crest length of 520 ft and a 160-ft, centrally located, ungated overflow spillway. The height of above foundation is 126 ft and 86 ft above the existing channel with a 20-ft crest width in the nonoverflow section. The slope of the downstream face was .85 horizontal to 1 vertical to facilitate free forming of the downstream face. The upper 24 ft of the downstream face of the dam (adjacent to the spillway) was constructed using vertical concrete facing panels as was the upstream face. An 80-ft long hydraulic jump-type stilling basin was located at the toe of the structure. This stilling basin consists of a 12-ft-thick RCC base slab integrally constructed with an RCC endsill and RCC gravity training walls. The spillway was designed to discharge a flow of 38,950 cfs. The full width of the spillway crest was surfaced with a two-foot thickness of wet-mix shotcrete for a distance of 30 ft, until it transitions to the natural RCC surface. A fixed orifice in the intake tower regulates discharge to a maximum of 60 cfs. This discharge rate was sized to drain the reservoir in 20 days and produce minimal flows in the downstream channel. An intake tower, attached to the upstream face of the dam, provides inlet control for increasing heights of sediment deposition. The tower, a typical U.S. Soil Conservation Service design, consists of a double weir overflow at the top and portal intakes at 5-ft intervals along two sides of the tower. These portals, sealed as sediment from periodic impoundment, accumulates against the structure. The structure is designed to be an unmanned project. Discharged water flows through a 48-in. outlet pipe cast in the RCC dam and training wall into an impact basin. Subsequent low velocity flows are channelized and eventually discharged into the natural channel.

d. Floodway channel.

(1) A natural water course below the dam, incised into the canyon, channels water flow until it reaches the city limits where the natural channel widens out at west 7th Avenue and Vancouver. At that point the channel improvements consist of a concrete intake structure with trash racks and an earthen dike to funnel flows of 400 cfs into a buried conduit consisting of a 78-in. reinforced concrete pipe. The conduit proceeds east on West 7th Avenue then north on Rainier Street to the golf course where it flows out from a concrete stilling well and follows a natural drainage path through the golf course. From Canal Drive, which borders the golf course on the north side, the water flows through a 6- × 8-ft concrete box culvert with a capacity of 620 cfs under Canal Drive to the Burlington Northern Railroad fill where a 78-in. diameter steel culvert was jacked through the fill to be able to pass flows up to 620 cfs with 3-ft of freeboard on the railroad fill.

(2) Downstream of the railroad fill, a 200-ft floodway dike was constructed to elevation 383.5 between Highway 395 fill to the high ground near the Union Pacific Railroad. An opening was left in the dike to allow train traffic to continue, with a stockpile of material near by to fill in the opening when flows exceed. The lower Zintel Canyon water course, also know as Tweedt Canyon Drain, is a combination of natural flow channels, low bridge crossings, and culverts crossings under embankments. Depending upon flow magnitude, water will either flow completely through the area in a series of existing channels and culverts or escape the watercourse and proceed to the east of Highway 395 overpass to the Columbia River.

e. Construction operations (Photos C-1 through C-7).

(1) Crushed basalt rock (140,000 tons) for the RCC was produced from a quarry located only a few hundred feet upstream of the dam right abutment. The quarry area was developed using a dozer (Cat D9C) and ripper. A crushing operation was set up, and consisted of a primary jaw crusher, an impact crusher, and two roller crushers. The RCC mix required 29 to 32 percent of each rock product, 2.5-in. rock, 3/4-in. rock, fine aggregate, and approximately 6 percent added silt. Approximately 50 percent of the total required aggregate was produced prior to the start of RCC placement.

(2) Design parameters require the RCC to attain a minimum compressive strength of 1,400 psi at one year of age. Static stability requires cohesion values of 35 psi at the base of the structure, and lesser values in the upper regions of the dam. Subsequent dynamic analyses determined that lift joints also had to attain cohesion values of 50 psi in the upper regions of the structure. It was determined that the specified construction system had to provide joint quality that resulted in shear cohesion values exceeding 50 psi. The resulting mix attains a 1-year compressive strength of 2,200 psi, and displays laboratory cohesion values of 95 psi and 150 psi for unbedded and mortar-bedded lift joint configurations, respectively, at exposures of 24 hr at 70˚F. The paste-to-mortar ratio is approximately 0.50, the mortar volume is 23 percent, and the workability level is approximately 15 sec, measured using the modified vebe apparatus.

(3) Great economy is achieved when RCC production and placement can proceed uninterrupted at a consistent production rate. Repeatedly changing mix designs (e.g., for upstream and downstream richer RCC zones) creates placing problems, and limits equipment selection. Consequently, only a single RCC mixture was produced for Zintel Canyon Dam, so that continual plant changes were not required. This is especially beneficial for continuous mixing operations, since there is usually no convenient method of instant and frequent mix changes. Several other mixes were used on the project. A higher cement content mix, with an air entraining admixture, was used for the top two ft of the stilling basin slab, as well as for the top four lifts of the dam. A low cement content mix, with an air entraining admixture, was used for the top four lifts of the training walls.

(4) Precast panels for vertical face construction were fabricated in a commercial precast facility 100 miles from the project and then trucked to the site. The panels, 4 ft by 16 ft in width and 4 in. thick, were keyed along the horizontal joints. The

panels were anchored into the RCC with 8-ft coil rods (3/4-in. diameter) and end plates. Panels were used for the vertical faces of the stilling basin training walls and for the above-grade vertical surfaces of the upstream face of the dam.

(5) Panels were placed in a checkerboard configuration so that intermediate panels were supported by previously placed and anchored panels. This eliminated the need for external bracing. The checkerboard method of panel installation is a very economical panel system, however, tight alignment tolerances are difficult to achieve. The specified alignment tolerances were purposely broad so that such a panel installation system could be utilized.

(6) The sloping surfaces were to be a free-formed RCC slope. In order to dress these slopes, the free slopes had to be trimmed with a backhoe bucket periodically. This produced the relatively uniform appearance of the slope, and removed the uncompacted RCC on the slope.

(7) RCC was conveyed from the plant to the placement and discharged directly into front-end loader (Cat 980) buckets. The material was driven to the specific placement location and dumped onto the uncompacted RCC surface. The dozer (Cat D4) spread the material in 14-in. thick layers. Compaction was done with a 10-ton double drum vibrator roller (Ingersol Rand DA-50), and supplemented with a smaller roller (Ingersol Rand DH-22). Edge compaction was done with a rammer (Wacker). Since Zintel Canyon Dam required only moderate shear performance at the lift joints, bedding mortar was applied to the lift joints to assure shear and tensile strengths, and vehicle transportation on the surface was allowed to reduce project costs. This arrangement did not jeopardize the lift joint quality and still provided significant equipment cost savings.

(8) RCC was placed in lifts 12 in. thick and mortar was applied to each lift surface. To minimize the impacts of mortar application, the contractor formulated a system to pump mortar to the placement and shoot the mortar on the surface. The mortar mix was modified with “a high range retarder” to produce phenomenal extended set times and reasonable strength performance. This process proved to be very effective in reducing manpower dedicated to mortar placement and provided uniform coverage of mortar. The retarder is a product originally developed to delay the setting of concrete, in transit mixers, for extended periods of time.

(9) Placement began in the key trench, with a placement of 16 lifts, totaling 1,800 cu yd. The RCC was conveyed to the placement and dropped to the rock or RCC surface by elephant trunk followed by dozer spreading and compaction. The placement area then expanded to the stilling basin slab, with 12 lifts averaging 1,400 cu yd. RCC was conveyed to loaders, and subsequently transported to the placement location. Loaders traveled as much as possible on fresh RCC surfaces rather than the older surfaces that were being prepared for the next lift. Upon completion of the stilling basin slab, the placement area narrowed to 84 ft and continued to narrow as the dam’s height increased. The RCC lifts for the stilling basin training walls were placed concurrently with each lift of the dam placements.

(10) Production rates averaged 50 cu yd/hr during the early key placements and the upper lifts (in the upper section of the dam). Typical production rates of 200 to 225 cu yd/hr were maintained during placement of the stilling basin and main dam lifts. The typical placing sequence was: 1) vacuum accumulated debris, ponded water, and segregated aggregate; 2) air clean the surface; 3) wet the surface; 4) apply bedding mortar; and 5) place the RCC.

(11) A drilling program commenced approximately 6 months after completion of the RCC placements. The purpose of the drilling was to remove 6-in. diameter cores from the structure and the foundation to evaluate the actual engineering properties of the RCC and the foundation rock. This testing provided excellent information for future design efforts using RCC. The testing showed that shear cohesion of the RCC lift joints more than doubled with the use of bedding mortar on the lift surfaces from 85 psi for unbedded lifts to 205 psi for bedded lift joints. The parent RCC containing no lift joint, tested at 290 psi.

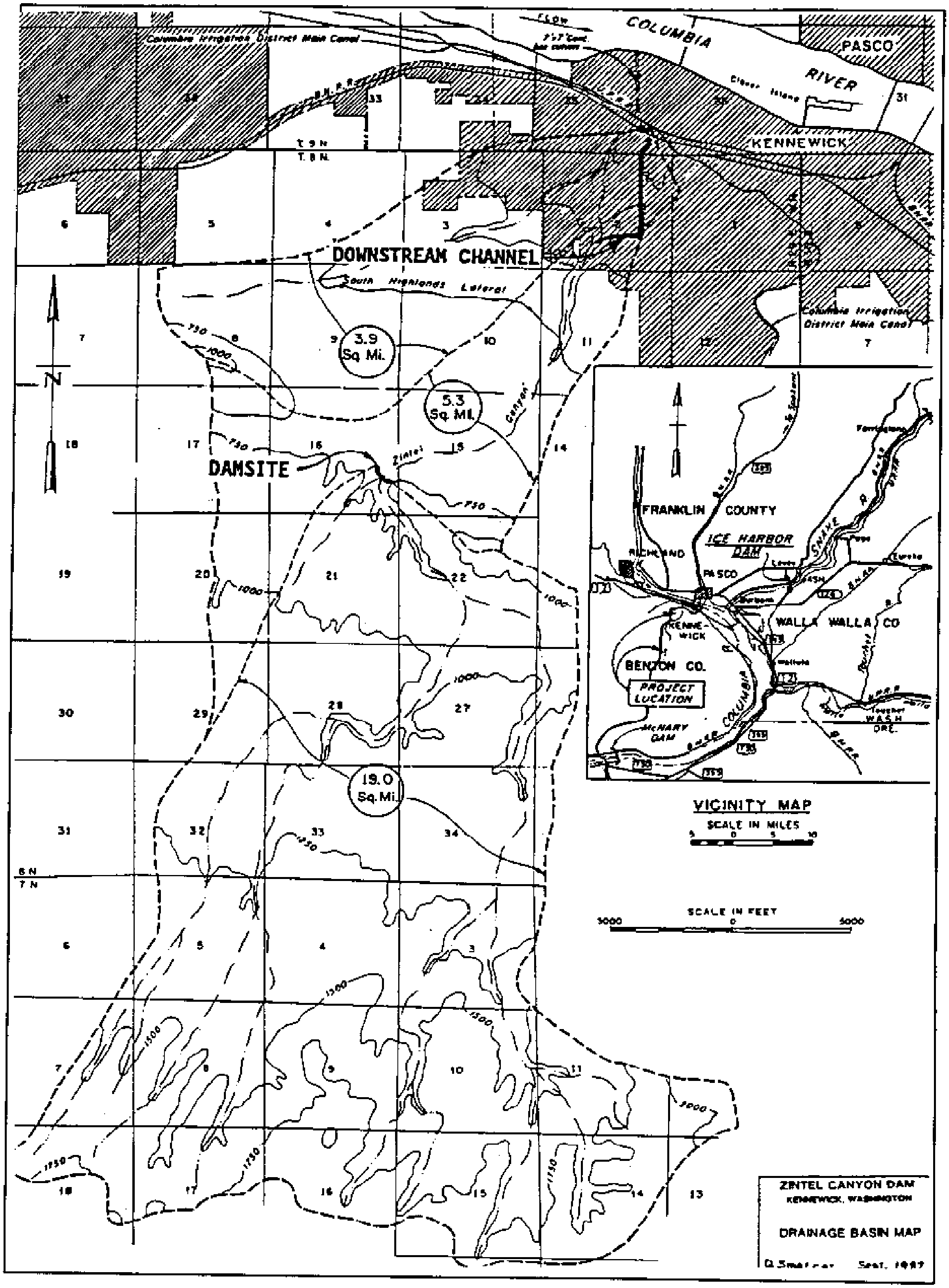

Figure C-1. Basin map

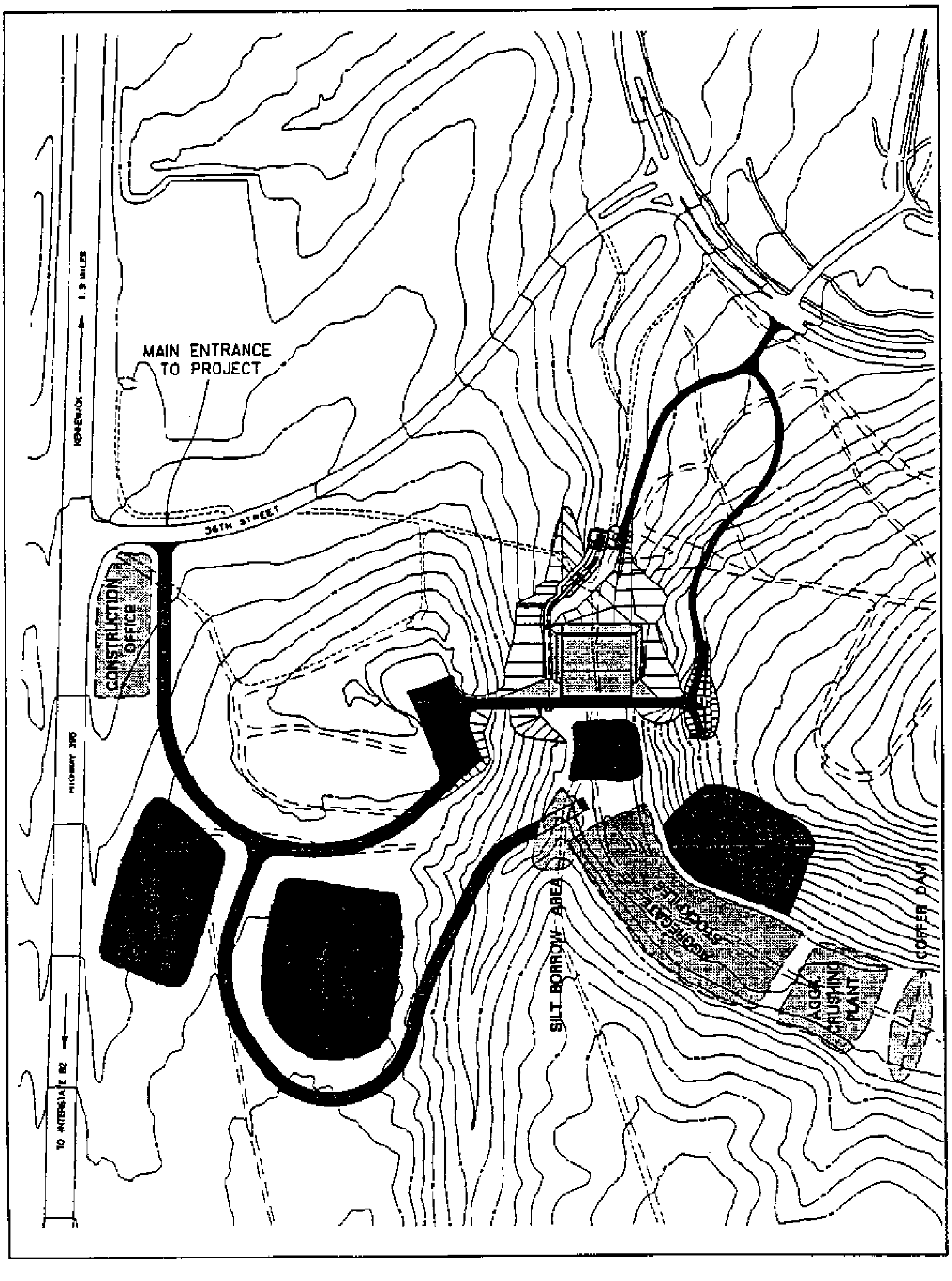

Figure C-2. Site plan

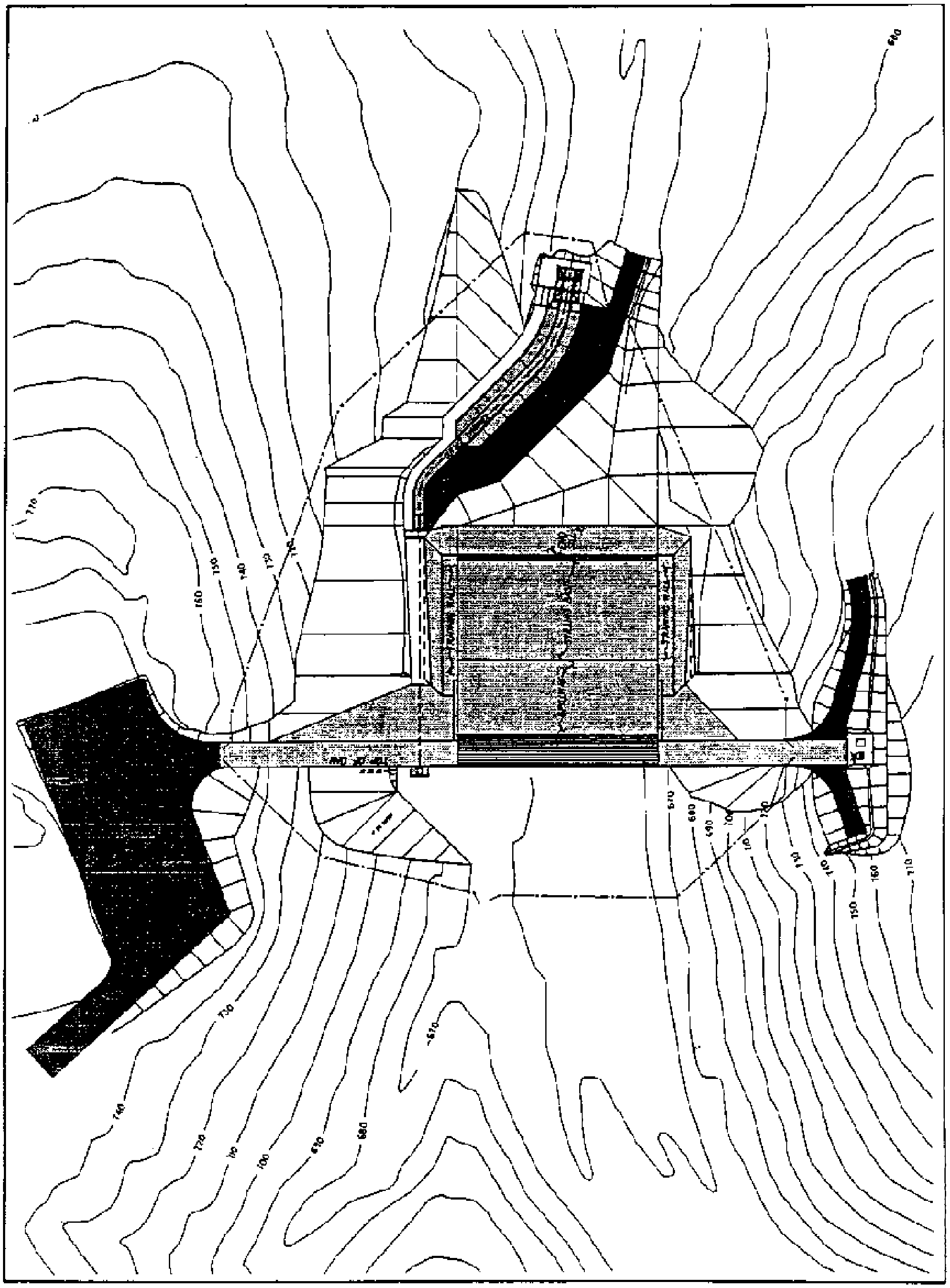

Figure C-3. Dam plan

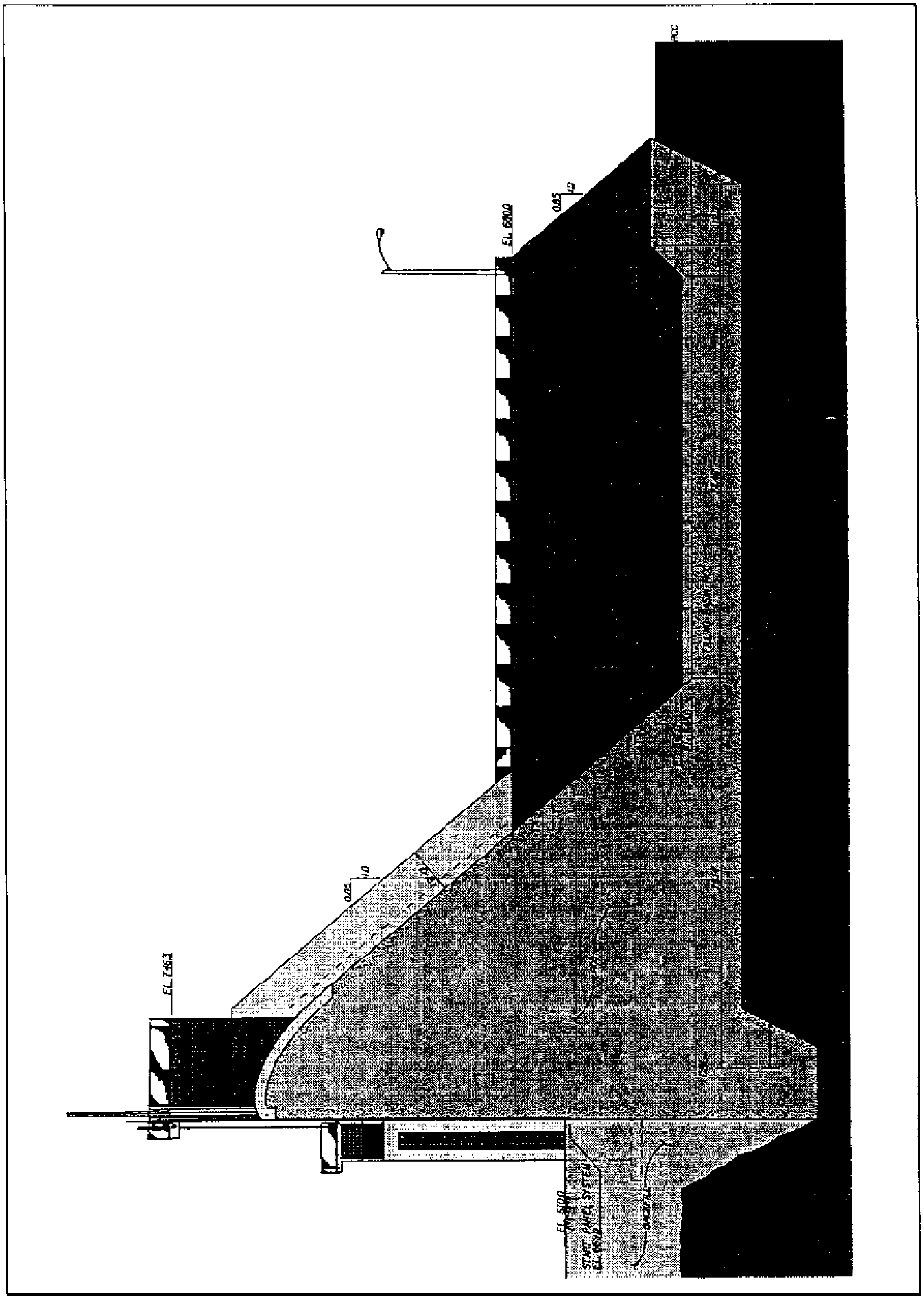

Figure C-4. Dam section

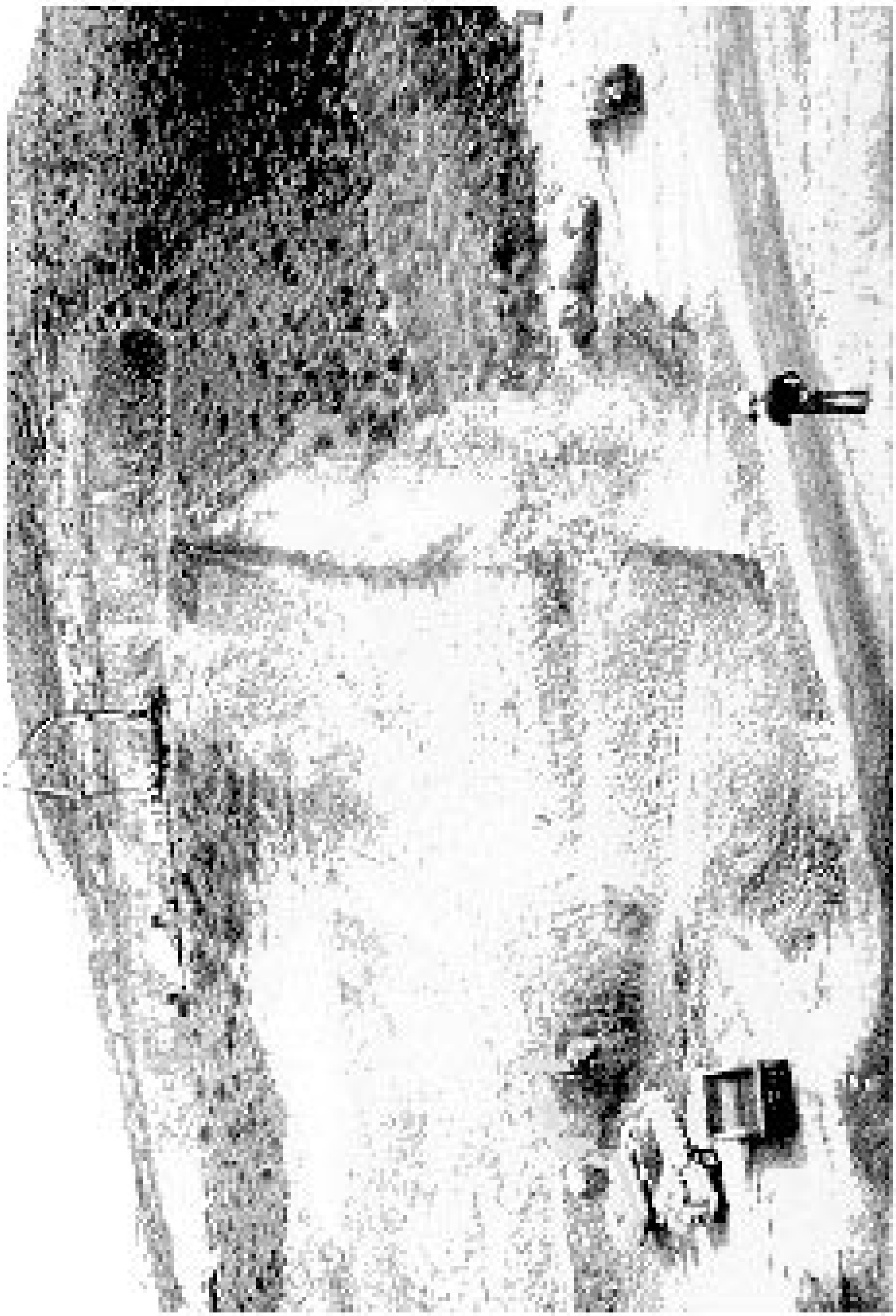

Photo C-1. Excavating basalt rock foundation

Photo C-2. Foundation after placement of concrete and shotcrete

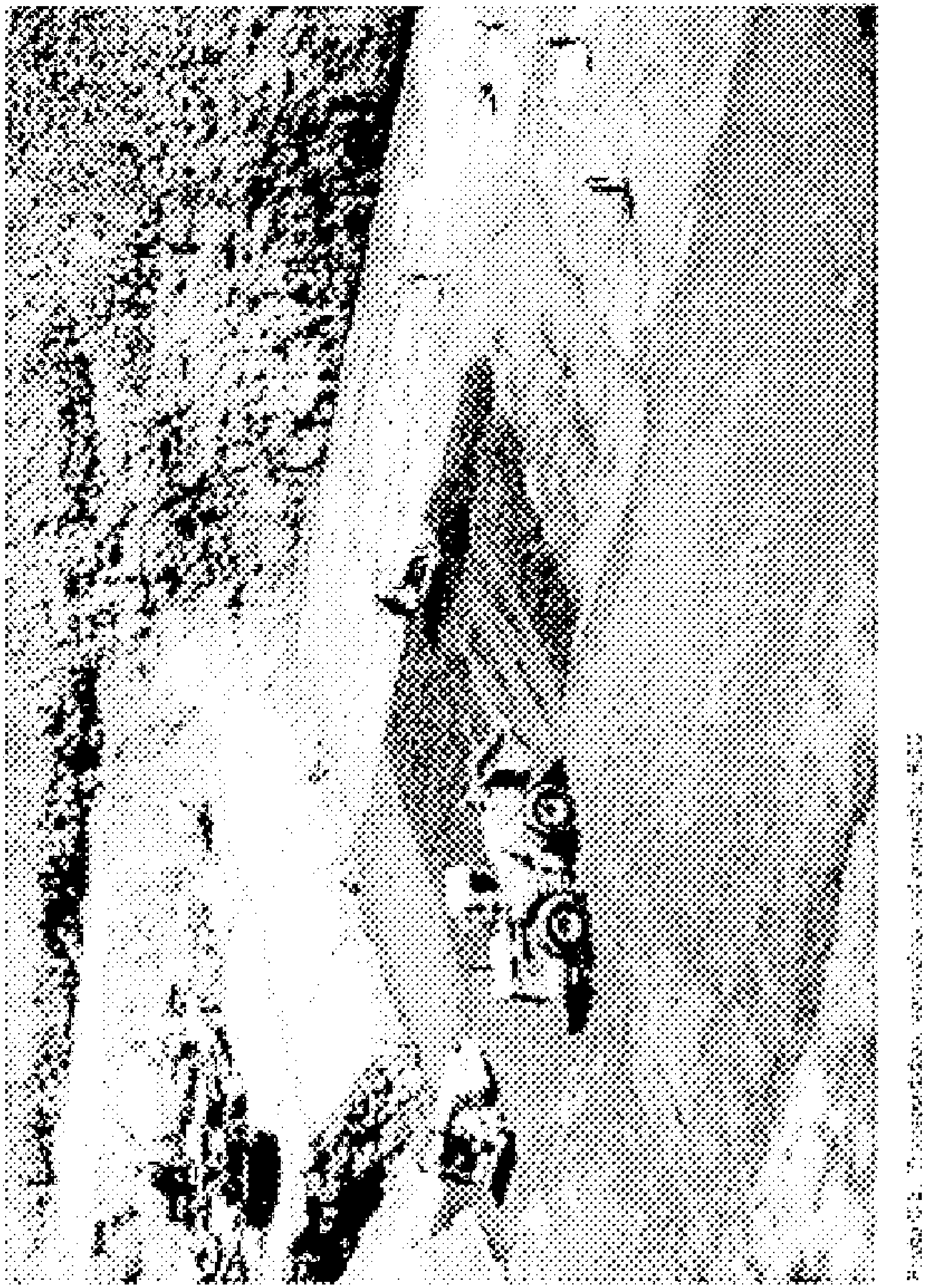

Photo C-4. Placing RCC [illegible] ft elevation above the top of the training wall

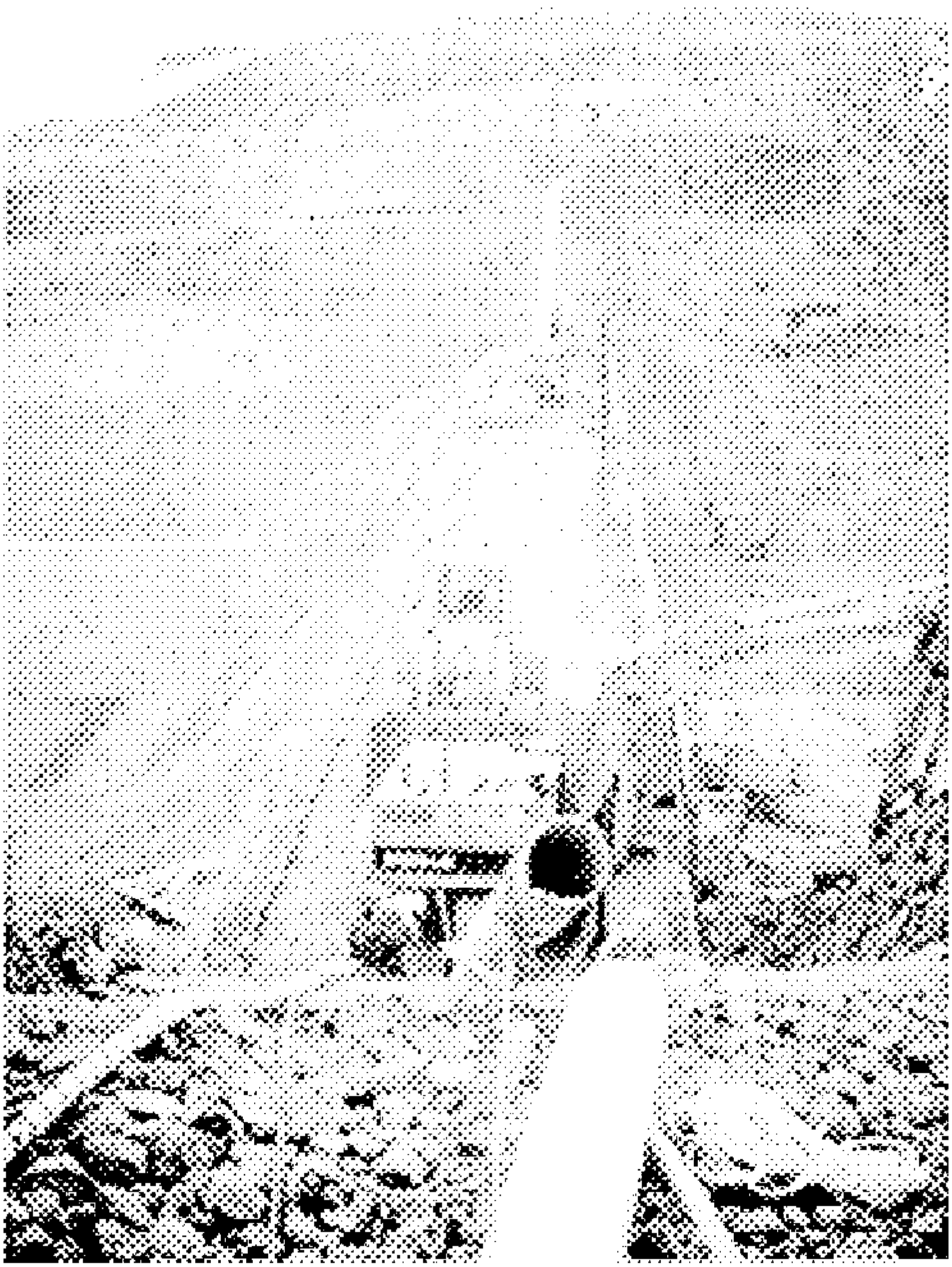

Photo C-6. Constricted placement conditions for RCC placement